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MONO-PROPELLANT CHARGE COMPOSITIONS

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The present invention relates to new and improved compositions of the kind which are used for the generation of a stream of hot gases at a predetermined pressure by their self-supporting exothermic non-detonating decomposition, for instance for the propulsion of rockets and the operation of pneumatically actuated mechanical devices. The invention relates more particularly to mono-propellant compositions and charges of the kind based on substantially anhydrous mixtures comprising ammonium nitrate and an organic fuel.

A mono-propellant composition comprising ammonium nitrate and an organic fuel is usually used in a rigid solid form which is obtained by compressing or casting the composition. It is often desirable, however, for a mono-propellant composition comprising ammonium nitrate and organic fuel to have the consistency of a putty or thick slurry which can be poured or extruded into a container in which its decomposition is to be brought about and wherein it can take the contour of the container and assume a level surface. This, however, is not easily achieved. The oxidising capacity of ammonium nitrate is too low to oxidise even to the stage of carbon monoxide and hydrogen the quantity of most liquid organic fuels which would be required to confer the desired degree of flow on the resulting mono-propellant composition. Also if a mono-propellant composition comprising ammonium nitrate and an organic fuel is produced from the limited range of available liquid organic fuels the oxygen deficiency of which is so small that they could be used in amount sufficient to enable the thus formed mono-propellant composition to adapt its shape to a container the ammonium nitrate would soon segregate out.

According to the present invention a mono-propellant composition having the consistency of a putty or thick slurry comprises a stable homogeneous dispersion of at least one solid oxidising agent consisting of at least mainly of powdered ammonium nitrate in a viscous solution comprising an organic thickening agent of oxygen deficient character incapable by itself of supporting a thermal decomposition into wholly gaseous products and a substantially non-explosive organic mono-propellant liquid solvent therefor, in which dispersion the content of solid oxidising agent is such as to permit substantially all the carbon and hydrogen of the organic constituents to be convertible into gaseous products.

In accordance with the present invention the process for the production of a mono-propellant composition having the consistency of a putty or thick slurry comprises homogeneously dispersing such a quantity of at least one solid oxidising agent consisting of at least mainly of pow-

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dered ammonium nitrate in a viscous solution comprising an organic thickening agent of oxygen deficient character incapable by itself of supporting a thermal decomposition into wholly gaseous products and a substantially non-explosive organic mono-propellant liquid solvent therefor that in the resulting dispersion the content of solid oxidising agent is such as to permit all the carbon and hydrogen of the organic constituents to be convertible into gaseous products.

The term "mono-propellant composition" is used herein to refer to a composition which is capable and which includes at least one compound which is capable of undergoing without detonation an exothermic decomposition in the absence of an oxidising atmosphere into products at least mainly gaseous. The phrase "A substantially non-explosive organic mono-propellant liquid" is used herein to refer to a liquid which is capable of undergoing without detonation an exothermic decomposition in the absence of an oxidising atmosphere into products at least mainly gaseous.

The phrase "substantially non-explosive" with reference to the mono-propellant organic liquid is intended to mean that the sensitivity of the liquid to detonation by mechanical shock, friction or heat is insignificant.

Specially suitable liquid organic mono-propellant compounds are the nitric esters of saturated aliphatic monohydric alcohols or substitution derivatives of these containing only carbon, hydrogen, oxygen and nitrogen and not less than three carbon atoms in their molecule, or mixtures of any such nitric esters. The oxygen deficiency of each of these liquids is between 42.5 and 130% which means that between 42.5 and 130 g. oxygen per 100 g. of one of these liquids is theoretically required to convert the liquid into carbon dioxide, water and nitrogen. Suitable individual nitric esters include n-propyl and isopropyl nitrates, n-butyl nitrate, 2-methoxy-ethyl nitrate, 2-ethoxy-ethyl nitrate, nitro n-propyl nitrate and nitro n-butyl nitrate. Although amyl nitrate has rather too high an oxygen deficiency to be used alone, it may be used in admixture with, for example, nitro n-propyl nitrate whose oxygen deficiency is only 42.5%. The oxygen deficiencies of n-propyl nitrate, isopropyl nitrate and 2-ethoxy ethyl nitrate are practically the same, but of these 2-ethoxy ethyl nitrate decomposes the fastest as a mono-propellant and is the most effective in rendering the resulting ammonium nitrate containing slurry capable of self-sustained decomposition. For a like reason 2-methoxy ethyl nitrate is usually to be preferred to nitro n-butyl nitrate, although it has a slightly higher oxygen deficiency.

As the thickening agent there may be used any organic material which is soluble in the aforesaid mono-propellant organic liquid and which is capable of forming therein a viscous or gelatinous solution, for example natural resins or gum resins, synthetic resins, pitches, tars, fatty oils, fats and waxes, long chain fatty acids and cellulose esters. Specially suitable synthetic resins for solution in the organic mono-propellant liquids of the aforesaid nitric ester character are polymerised esters of unsaturated carboxylic acids such as alkyl and alkoxy-alkyl esters of acrylic or methacrylic acid or their inter-polymers, polymerised aromatic hydrocarbons such as polystyrene, polymerised carboxylic esters of unsaturated aliphatic alcohols, e.g. polyvinyl acetate. Solutions of

suitable viscosity may be prepared by dissolving the monomer of any one of said polymerised esters or hydrocarbons in the liquid nitric ester mono-propellant and heating the mixture. It would seem that the liquid nitric ester mono-propellant has a catalytic effect on the polymerisation of the monomeric esters of for instance methacrylic acid as it is often possible to omit the addition of a polymerisation catalyst. The thickening agent normally has a considerably higher oxygen deficiency than the organic mono-propellant liquid, e.g. polymerised methyl methacrylate has an oxygen deficiency of 192%, and pitches have an oxygen deficiency of 300%.

The other oxidising agents which may be included with the ammonium nitrate may be other oxidising salts for example sodium or potassium nitrate or persulphate or salts capable of catalysing thermal decomposition of ammonium nitrate, as for instance ammonium dichromate, potassium chromate or dichromate. The presence of metal salts however results in the formation of an inorganic residue when the composition is thermally decomposed.

The viscosity of the viscous solution constituting the fuel for the solid oxidising agents required to sustain the latter effectively in homogeneous dispersion may be achieved at will by a suitable choice from organic thickening agents of differing inherent viscosity characteristics, solubility and oxygen deficiencies. In making up the slurry the solid oxidising agent particles and the viscous liquid organic fuel are worked together with suitable mechanical agitation to the desired consistency which will usually be that of a thick paste or soft putty.

The invention is illustrated by the following examples in which all the percentages are by weight.

Example 1

A composition consisting of ammonium nitrate passing a 180 B.S. sieve 42.9%, methyl methacrylate 14.4% and 2-methoxy-ethyl nitrate 42.7% is prepared as follows. The methyl methacrylate monomer is dissolved in the 2-methoxy-ethyl nitrate and the mixture is heated at 40° C. until no further increase in the viscosity is observed. No polymerisation catalyst is included. The ammonium nitrate is then worked into the viscous mixture in a McRoberts mixer. The resulting mixture has the consistency of a thick slurry. Slight separation of the ammonium nitrate takes place after 9 days. Its oxygen deficiency is 50 g. per 100 g. It can be transferred with the aid of wooden shovels into a metal container and ultimately finds its own level therein. When subjected to thermal decomposition in a decomposition chamber by igniting on top of it a layer of black powder about 0.1 inch thick it is capable of generating a stream of gases in self-sustained manner at a pressure of 500 lb./sq. in. and the calculated maximum specific impulse obtainable from the composition is approximately 147 seconds.

Example 2

A composition consisting of ammonium nitrate passing a 180 B.S. sieve 51.0%, methyl methacrylate 12.2% and 2-methoxy ethyl nitrate 36.8% is prepared as follows. The methyl methacrylate is dissolved in the 2-methoxy ethyl nitrate and the mixture is heated as described in Example 1 to polymerise the methyl methacrylate. The ammonium nitrate is then worked into the composition in a Werner Pfeleiderer Incorporator. The resulting composition has an oxygen deficiency of 40% and the consistency of a putty. It can be extruded under slight pressure into a decomposition chamber in which it ultimately finds its own level. Slight separation of the ammonium nitrate occurs after 14 days. This composition is capable of sustaining non-detonating thermal decomposition at a pressure of 500 lb./sq. in.

Example 3

A composition consisting of ammonium nitrate 62%, 2-ethoxy-ethyl methacrylic 11.5% and 2-methoxy ethyl nitrate 26.5% is prepared as follows. The 2-ethoxy-ethyl methacrylate is dissolved in the 2-methoxy-ethyl nitrate and heated at 40° C. in order to polymerise the methacrylic ester and the ammonium nitrate is worked into the resulting viscous liquid as described in Example 2. The oxygen deficiency of the composition is 30% and it has the consistency of a putty. No separation of the ammonium nitrate occurs after 90 days. When introduced into a decomposition chamber and ignited as described in Example 1 it is capable of self-sustained non-detonating thermal decomposition at a pressure of 500 lb./sq. in., and its calculated maximum specific impulse is 179 seconds.

Example 4

A composition consisting of ammonium nitrate 41.9%, methyl methacrylate 14.4%, 2-methoxy-ethyl nitrate 42.7%, and ammonium dichromate 1.0% is prepared as follows. The mixture is made in a similar manner to that described in Example 2 and is a thick slurry capable of supporting self-sustained non-detonating thermal decomposition at 500 lb./sq. in. Slight separation of the ammonium nitrate occurs after 9 days. Its oxygen deficiency is approximately 50%. The ammonium dichromate serves to increase the rate of decomposition of the ammonium nitrate and hence increases the thrust obtained in its environment more nearly to that theoretically possible from the composition.

Example 5

A composition consisting of ammonium nitrate 65.5%, coal tar 11.5%, pitch 11.5% and 2-ethoxy-ethyl nitrate 11.5% is prepared as follows. The coal tar and the pitch are first worked together with the 2-ethoxy-ethyl nitrate to form a dark solution of the same order of viscosity as treacle into which the ammonium nitrate is worked in a dough mixer. The resulting dark mixture has the consistency of a sticky paste which is capable of slow flow so that it will adapt its shape to that of a decomposition chamber. No separation of the ammonium nitrate occurs after 50 days. The composition has an oxygen deficiency of 70% and when ignited as in Example 1 is capable of self-sustained non-detonating thermal decomposition at 500 lb./sq. in.

The compositions of Examples 1-5 yield very little smoke and the compositions of Examples 1-3 and 5 leave no inorganic residue.

What we claim is:

1. A thickened mono-propellant composition consisting essentially of a stable homogeneous dispersion of a solid oxidizing agent which is essentially powdered ammonium nitrate dispersed in a viscous solution of an organic thickening agent selected from the group consisting of natural resins, gum resins, synthetic resins, pitches, tars, fatty oils, fats, waxes, long chain fatty acids and cellulose esters, and dissolved in a substantially non-explosive organic mono-propellant liquid solvent therefor, said solvent being a liquid nitric ester of a lower saturated aliphatic monohydric alcohol, containing not less than 3 carbon atoms and having an oxygen deficiency of between 42.5 and 130%, the available oxygen content of said oxidizing agent being sufficient to permit all of the carbon and hydrogen in the organic constituents to be convertible into gaseous products.

2. A mono-propellant composition as claimed in claim 1 wherein said nitric ester is selected from the group consisting of n-propyl nitrate, isopropyl nitrate, n-butyl nitrate, 2-methoxy-ethyl nitrate, 2-ethoxy-ethyl nitrate, nitro n-propyl nitrate and nitro n-butyl nitrate.

3. A mono-propellant composition as claimed in claim 1 wherein said solvent is 2-methoxyethylnitrate.

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4. A mono-propellant composition as claimed in claim 1 wherein said solvent is 2-ethoxyethylnitrate.

5. A composition according to claim 1 including an inorganic chromate salt.

6. A process for the production of a mono-propellant composition as defined in claim 1 which comprises homogeneously dispersing said solid oxidising agent in said viscous solution of organic thickening agent dissolved in said substantially non-explosive organic mono-propellant solvent.

7. A process as claimed in claim 6 which comprises preparing said viscous solution by dissolving the mono-

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mer of an ester of an unsaturated aliphatic monocarboxylic acid in the liquid nitric ester mono-propellant and heating the mixture thus produced.

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